Curriculum reform and restructuring of senior secondary science education in Hong Kong: Teachers' perceptions and implications

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Abstract

With the restructuring of the senior secondary education system in Hong Kong in 2009, the senior secondary curriculum was overhauled substantially by the conversion of the two-year Certificate Level and the two-year Advanced Level to a new three-year senior secondary level. This process entails changes to the contents and organization of various science subjects. This study was designed to explore, through questionnaires and interviews, the perceptions of science teachers about the design of the three science curricula, namely Physics, Chemistry, and Biology, and the challenges teachers perceived for teaching and learning these subjects in the new education context before the full implementation of the reform. The findings show that the respondents were well aware of the emphases of the new curricula. However, the respondents were likely to experience difficulty in putting rhetoric into practice due to limitations inherent to the curriculum design, increased diversity of students' ability, teachers' inertia in changing old practices, and resource constraints.

Keywords: science curriculum, curriculum reform, senior secondary science, Hong Kong

Introduction

In response to the socioeconomic and political changes that are increasingly influenced by Mainland China and other major trading partners (see, e.g., Bray and Lee, 2001), the government of Hong Kong Special Administrative Region (HKSAR) has initiated a number of large-scale education and curriculum reforms since 2000 (see, e.g., Morris and Adamson, 2010). The basic aims of these reforms are to continually enhance the quality of education and to lead students toward the way for lifelong learning so that Hong Kong could truly sustain its development toward a knowledge-based society. In 2001, the Curriculum Development Council (2001, 2002) released a major curriculum document titled "Learning to Learn," which built the cornerstone for the reform to attain a "more flexible and diversified, and student learning more enjoyable and effective" curriculum (Education and Manpower Bureau, 2005, p. 9). Subsequently, a comprehensive review of the restructuring of the academic structure and curriculum of the senior secondary (i.e., secondary 4 to 6) education in 2005 to 2007, leading to a number of new curriculum and assessment guides for all senior secondary subjects in every key learning area (see, e.g., CDC and HKEAA, 2007a, 2007b, 2007c, and 2007d), was conducted. Overall, the academic structure of the senior secondary and the tertiary level was converted from the British system of the two-year Certificate Level (CEL) at S4-5 (or Grades 10 to 11) + two-year Advanced Level (AL) at S6-7 (or Grades 1 to 13) + three-year undergraduate level to the Chinese (as practiced in both Mainland China and Taiwan), or the American system of three-year senior secondary level at S4-6 (or Grades 10 to 12) + four-year undergraduate level. The new senior secondary education reform would be geared toward the implementation of the 12-year compulsory education in Hong Kong to provide a flexible and more comprehensive/general knowledge base for all youngsters. The development marks a significant shift from that of the conventional academic curriculum for the selection of elites as adopted from the British educational system for many years. Moreover, it attempts to dilute the past practice of clear demarcation between the arts and science stream of study by introducing a new compulsory subject (CDC and HKEAA, 2007e) called Liberal Studies (in addition to existing Chinese, English, and Mathematics as the other three core subjects), which adopts an integrated approach in its curriculum design (see, e.g., Maurer, 1994; Wineburg and Grossman, 2000; Haynes, 2002). The three-year New Senior Secondary Curricula (NSSC) was set for implementation in all Hong Kong secondary schools in 2009 (Curriculum Development Council, 2009), and its introduction was expected to pose challenges to both science teachers and their students. For the new senior secondary science curricula (Physics, Chemistry, Biology and Integrated Science), nature of science, scientific inquiry, science-technology-society-environment would be put in emphases and school based assessment will be compulsory to all science subjects. Lee, Lam and Yeung (2010) had undergone a critical review of the NSS science curricula on Physics, Chemistry, Biology and Integrated Science. The changes in the curriculum and assessment might affect frontline teachers' implementation in classroom and before its implementation; we have started to carry out this study to address the following research questions:

(a) What are the teachers' perceptions about the NSS science curricula with regard to the understanding of the curricula, perceived emphases of the curricula, perceived level of the curricula?

(b) What are the gaps between the intended NSS science curricula and the classroom implementations with regard to the teaching emphases for the core and elective parts, progression of contents, progression from the junior to senior secondary level, strategies to deal with mixed ability and pedagogy?

(c) What are the perceived difficulties in school based assessment?

Research methodology

This study was a subset of a large research project, which aimed at the comprehensive investigation of the NSSC before its actual implementation in Hong Kong. The full project team involved nine independent investigators who were assigned to deal with the four core subjects of the NSSC (i.e., Chinese Language, English Language, Mathematics, and Liberal Studies), together with some academic subjects from Key Learning Areas (KLAs) of Personal, Social, and Humanities Education (Geography), and Science Education (Physics, Chemistry, Biology, and Integrated Science). Additionally, another investigator targeted at the school administrators and/or policy makers. The three science educators with expertise in Physics, Chemistry, and Biology formed a close collaborative team to develop the relevant research instrument to collect qualitative and quantitative data from curriculum planners and school teachers in the Science Education KLA. Based on a critical review of all NSS science curricula together with a detailed comparison with the previous curricula at the S4-5 and S6-7 levels (Lee, Lam, and Yeung, 2010), a set of semi-structured interview questions (see Appendix I) and guidelines were developed to collect qualitative data from the curriculum planners (see Table 1). Using the preliminary findings from the curriculum planner interviews, the research instrument was modified and refined to collect further qualitative data from the science teachers in schools, and four sets of similar questionnaires were developed for collecting quantitative data from teachers of the four science disciplines. Each questionnaire consists of 4 parts, namely Part I on educational system and curriculum, Part II on the NSSC Physics/Chemistry/Biology/Integrated Science, Part III on impression of NSSC and Part IV on personal particulars. For Part II, there are 12 key questions and around 80 items with minor differences as reflected by subject nature and some questions are given in Appendix II. To ensure the validity and reliability, each questionnaire instrument has undergone around five times of revision by the authors (who are subject experts with many years of experiences on training teachers) and by the project team in a number of research meetings. Specific reference or modification was also made from the initial work of the central team or other subjects. The questionnaires (with two sets per subject per school) for the nine NSSC subjects and for the school administration were sent to 120 secondary schools (about a quarter of the total number in Hong Kong) randomly selected for the survey. The relevant statistics for the questionnaire survey are reported in Table 1 below.

Table 1. Statistics on interviews conducted with curriculum planners and subject teachers/panel heads and questionnaire survey of subject teachers in various science disciplines

	Number of interviews with		Questionnaire survey:	
Subject	curriculum planners	teachers/ panel heads*	Number of valid questionnaires received*	Valid response rate based on schools
Physics	3	11 (7)	97 (67)	55.8%
Chemistry	3	16 (10)	111 (74)	61.7%
Biology	2	15 (11)	108 (73)	60.8%
Integrated Science	3	3 (2)	44 (25)	24.2%

*Number of schools involved is given in parentheses.

Almost all the interviews were audio-recorded and then transcribed into computer files; meanwhile, the survey data were analyzed by the SPSS (involving Student's t-test, Levene's test on homogeneity of variances, ANOVA and Welch's test on equality of means for 3 or more items, and exploratory factor analysis) for comparison with all other NSSC subjects and among the science subjects only. We were aware that the quantitative data should be analyzed properly by the Rasch model or Item Response Theory (see, e.g., Bond and Fox, 2007; Liu and Boone, 2006). However, to simplify the presentation and interpretation of our findings, we put aside those findings as analyzed by the Rasch model. Furthermore, we need to exclude the Integrated Science subject because the validity and reliability of the limited data collected from the corresponding teachers could not be ensured at an acceptable level.

Results and discussion

As shown in Table 1, 97 Physics teachers, 111 Chemistry teachers, and 109 Biology teachers responded to the questionnaire survey. The valid response rate (based on school) was around 56 to 62%. Among the 11 Physics teachers interviewed, five are Physics panel with 11 to 28 years of teaching experience; the other five are graduate master, having four to 14 years of teaching experience. The remaining one is a vice principal. With the exception of one overseas graduate and one engineering degree holder, most of them obtained their BSc in Physics from a local university. Almost all of them have already received proper teacher training. Of the 16 Chemistry teachers interviewed, only two had taught Chemistry for less than five years. Four respondents had five to 15 years of experience, and the rest had over 15 years' experience. All teachers had obtained teacher qualification, except for one who was still receiving in-service teacher training. Among the Biology teachers, two had taught for five years or less, one has eight years of experience, and the rest had taught for over 10 years. All had obtained teacher qualification with the exception of one who was receiving in-service training. In this study, we shall interpret and discuss only the findings from the nine aspects of the interview and questionnaire survey data of school science teachers in the following subsections.

1 Understanding of the curriculum

Table 2 (under a six-point Likert scale with 1 = lowest and 6 = highest) reveals the teacher's level of understanding of the curriculum, which includes the elective topics, teaching methods, SBA, and public examination. The Physics teachers generally have a better understanding of the Atomic World and Energy electives than that of the Astronomy and Space Science and Medical Physics electives. The difference is statistically significant at $p < 0.000$ under the Welch test (for inhomogeneous variances) with statistic = 24.690. Their understanding of the teaching methods, SBA, and public examination lies between the aforementioned two types of electives with no statistically significant difference. The Physics teacher interviewees explained that the subject knowledge for the Atomic World and Energy electives had been learned from their own undergraduate studies, whereas Astronomy was covered at one local university, but not the other one. Medical Physics was unknown to most of them. Most of them favored the

Astronomy course offered by the Education Bureau (EDB) of the HKSAR government, but some viewed other courses as less useful to them.

Table 2. Average scores (with standard deviations given in parentheses) for science teachers' understanding of the curriculum (in a six-point Likert scale) as collected from the questionnaire survey

	Physics	**Chemistry**	**Biology**
A. Elective content knowledge			
1. Elective 1 topic	*Astronomy and Space Science*	*Industrial Chemistry*	*Human Physiology: Regulation and Control*
	4.1 (1.04)	4.8 (0.75)	5.3 (0.58)
2. Elective 2 topic	*Atomic World*	*Materials Chemistry*	*Applied Ecology*
	4.8 (0.76)	4.2 (1.01)	5.1 (0.69)
3. Elective 3 topic	*Energy and Use of Energy*	*Analytical Chemistry*	*Microorganisms and Mankind*
	4.7 (0.76)	5.0 (0.70)	4.8 (0.76)
4. Elective 4 topic	*Medical Physics*	N/A	*Biotechnology*
	4.0 (0.91)	N/A	4.9 (0.74)
B. Teaching methods	4.6 (0.70)	4.9 (0.59)	4.9 (0.68)
C. School-based assessment	4.3 (0.94)	4.7 (0.65)	4.6 (0.83)
D. Public examination	4.4 (0.92)	4.7 (0.65)	4.5 (0.83)

The Chemistry teacher interviewees were generally aware of the content of the curriculum, and all of them agreed that the contents, except for the elective Materials Chemistry, are not new to them. The questionnaire survey also revealed that Chemistry teachers have a better understanding of Analytical Chemistry with an average score of 5.0, and Industrial Chemistry with an average score of 4.8, than Materials Chemistry with an average score 4.2. The difference is statistically significant at $p < 0.001$ under the Welch test with statistic = 22.0. Their understanding of the teaching methods, SBA, and public examination lies between the electives Materials Chemistry and Analytical Chemistry, but no statistically significant difference is found between them. Some interviewees reflected that they did not have any training in Materials Chemistry in university, and some of the contents, such as the topic of liquid crystals, were not covered in the existing CE level and A-level.

The Biology teachers surveyed generally expressed a fair understanding of the new curriculum. The level of understanding was highest with respect to the teaching approach suggested in the curriculum (4.83), and lowest regarding SBA (4.44). As to the respondents' familiarity with elective modules, teachers were most familiar with Human Physiology (5.3), followed by Applied Ecology (5.1), Biotechnology (4.9), and Microorganisms and Mankind (4.8). The difference is statistically significant at $p < 0.001$ under the F-test (for homogeneous variances) with statistic $F(3, 432) = 13.3$. The Biology teacher interviewees were generally aware of the content of the curriculum, but they still needed more in-depth study to familiarize themselves with the specifics. Most of them agreed that it was rather difficult to gauge the depth of knowledge required solely from the very concise descriptions in the curriculum guide.

Aside from the understanding of the subject content knowledge of the electives, teachers were also asked about their understanding of the teaching methods, SBA, and public examination. Teachers of these three science subjects generally rated teaching methods higher than that of the latter two aspects. Across subject disciplines, the average score of Chemistry teachers was statistically higher than that of Physics teachers in each of these three aspects, with $p < 0.001$ under the Welch test (for inhomogeneous variances). The corresponding scores for the Biology teachers lie between those of the other two science teachers, but the difference is not significantly significant. Further analysis and discussion of these three aspects are given in Subsections 4, 8, and 9.

2 Perceived emphases of the curriculum

As shown in Table 3, our questionnaire instrument included an item (in a six-point Likert scale with 1 = lowest and 6 = highest) to probe the science teachers' perceived emphases of their respective curriculum in several key areas, namely, disciplinary content knowledge, disciplinary practical and investigation skills, NOS (nature of science), STSE (Science, Technology, Society, and Environment), scientific attitudes, and problem-solving ability (for Physics only). From an exploratory factor analysis, there is only one factor found and it involves the items #3-5 (i.e. NOS, STSE and scientific attitudes) with very high factor loading of 0.81 to 0.86. Those items are new emphases of the NSSC science subjects and the teachers' perception of them seems to be not closely correlated with those of the traditional emphases (i.e. items #1 and #2). For the Physics teachers' average score, there is a statistically significant difference across these six aspects of emphases, with $p < 0.001$ under the F-test with statistic $F(5,575) = 12.7$. These respondents generally perceived that content knowledge (average score = 5.3) and problem-solving ability (average score = 5.1) still predominate in the new curriculum, although increased emphasis was placed on practical and inquiry skills as well as scientific attitudes. Compared to the above aspects, NOS (average score = 4.7) and STSE (average score = 4.6), which have been strongly stressed in the new curriculum, were rated with significantly lower emphasis based on the statistical test. Most Physics interviewees did not (or avoided to) say anything about the teaching of NOS explicitly in their classes; on the other hand, a few merely mentioned that NOS might be implicitly included in teaching the history of some important scientific developments. For STSE, most interviewees indicated that relevant issues will be mentioned in a normal way as factual information (i.e., just let students know about the social, health, and environmental impacts or effects without any in-depth discussion or debate) when they teach nuclear energy, which is often considered to be one of the few topics with STSE components in the Physics curriculum. They would prefer to spend more time on scientific concepts and techniques for answering public examination questions. Hence, most Physics teachers under this study were found to still hold a traditional view of the Physics curriculum and were not responsive to the current global trend of science education in stressing NOS and STSE (see, e.g., Yager, 2004; Flick and Lederman, 2006; Abell and Lederman, 2010).

Table 3. Average scores (with standard deviations given in parentheses) for science teachers' perceived emphases of the curriculum (in a six-point Likert scale) as collected from the questionnaire survey

Aspect of emphasis	Physics	Chemistry	Biology
1. Disciplinary content knowledge	5.3 (0.65)	5.3 (0.57)	5.4 (0.58)
2. Disciplinary practical and investigation skills	5.0 (0.71)	5.1 (0.68)	5.2 (0.60)
3. NOS	4.7 (0.74)	4.7 (0.71)	4.9 (0.72)
4. Inquiry of STSE issues	4.6 (0.72)	4.6 (0.63)	5.0 (0.73)
5. Scientific attitudes	4.9 (0.78)	4.7 (0.77)	4.8 (0.78)
6. Problem-solving ability	5.1 (0.69)	N/A	N/A

From the Chemistry teachers' survey data, a statistically significant difference across the first five aspects of emphases appears, with $p < 0.001$ under the Welch test with statistic = 23.4. These respondents put higher emphasis on subject knowledge (average score = 5.3), and practical and inquiry skills (average score = 5.1) than STSE, NOS, and scientific attitudes, with an average score ranging from 4.6 to 4.7, although NOS and STSE have been stressed in the new curriculum. The interviewees generally agreed with the emphases, but most interviewees did not say anything about the teaching of NOS. Only one interviewee reflected that there were some constraints in teaching NOS. He claimed that students did not have sufficient comprehension and critical thinking skills, adding that large class size, limited teaching resources, and limited time also posed problems in carrying out the discussion of NOS. He suggested that EDB could design and provide teaching materials about NOS. For STSE, most interviewees thought that relating Chemistry with daily life is a good approach. They said they would use newspaper cutting and socio-scientific issues like melamine, stopping the production of specific isotope used for medical treatment such as Molybdenum 99 in the United States, to arouse student interest. Rather surprisingly, the questionnaire survey showed that teachers had the least difficulty in teaching NOS, with a score of only 3.8 (under a six-point Likert scale with 1 = the least difficulty and 6 = the most difficulty). The reason may be probably due to the less emphasis they put on this issue.

From the Biology teachers' survey data, a statistically significant difference across the first five aspects of emphases also appears, with $p < 0.001$under the F-test with statistic $F(4,540) = 14.6$. These respondent teachers tended to support the three teaching emphases laid down in the curriculum guide, namely, scientific inquiry (average score = 5.20), inquiry into STSE issues (average score = 5.00), and NOS (average score = 4.90), as evidenced by the relatively high perceived importance of these emphases compared to those perceived by the Physics and Chemistry teachers. However, when compared with these three curriculum emphases, subject knowledge was still accorded a higher degree of importance by the Biology teachers (average score = 5.40). The Biology teacher interviewees generally perceived that content knowledge still predominates in the new curriculum; nevertheless, they recognized that increased emphasis was placed on conceptual understanding and reasoning, communication, and application of these understandings, social issues, historical aspects, and self-directed learning. As to the three emphases of the curriculum, namely, scientific inquiry, STSE, and the nature of science (or Biology), the teachers agreed almost unanimously with the rationale provided by the curriculum planners. Scientific inquiry was perceived to be effective in cultivating scientific attitudes; STSE is ideal in linking foundation science with everyday life events, motivating students to learn science, and introducing values; and the nature of science is conducive to the development of critical thinking and values. Despite the general support for the inclusion of NOS in the curriculum, it seemed to be the least familiar and important aspect perceived by the respondents among the three emphases mainly because it was too abstract to be appreciated by students. Some teachers acknowledged that they were unfamiliar with the nature of science, and hence were not confident in teaching it in an interesting way, which is somewhat contradictory to the questionnaire finding. Most teachers' understanding of NOS appeared to be restricted to an appreciation of science, and the study of the NOS was equated with the study of the history of science. Nevertheless, one interviewee did point out that it would be difficult for students to appreciate the NOS simply by knowing about the historical development of science. Another interviewee suggested that the NOS be taught through inquiry activities and project work, because it would be too boring for students to learn this merely by listening to the teacher. These findings echo previous findings that many science teachers are unfamiliar with the effective methods of teaching NOS (McComas, 1998; McComas, 2004; Flick and Lederman, 2007).

3 Perceived level of the curriculum

The average scores and standard deviations for science teachers' perceived level of the 10 key components of the new curriculum (i.e., subject depth, subject breadth, generic skills, scientific attitudes, scientific investigation, practical skills, ability to discuss STSE issues, understanding of NOS, problem-solving ability, and values toward living things) are given in Table 4 in an eight-point quasi-Likert scale (with 0 = below S5, 1 = S5, …, 6 = S7, and 7 = above S7 level). An exploratory factor analysis on the first eight items (as common to all the three science subject) reveals that they all fall within a single factor with a very high eigenvalue of 5.2 and high factor loading value of 0.76 to 0.85, implying that there is a high level of correlation between those items as perceived by the respondent teachers.

Although the questionnaire data could not yield a very statistically significant difference (with sig. = 0.062 for the F-test with $F(8,863) = 1.87$) on the Physics teachers' responses, the academic level of the new physics graduates is believed to lie at around the middle point between that of current S5 and S7 graduates. On the other hand, the interviewees asserted that the level of subject depth was significantly lower, whereas the subject breadth noticeably increased. Many of them cited the same example that the relatively difficult topic of "Simple Harmonic Motion" was inappropriately deleted, leaving only a superficial understanding of circular motion. They thought that the new curriculum was mostly built upon the existing Cert Level Physics curriculum by adding some new topics that are more closely related to daily life. They generally welcome this approach despite some criticism on the lack of subject depth.

Table 4. Average scores (with standard deviations given in parentheses) for science teachers' perceived level of the curriculum (in an eight-point quasi-Likert scale with 0 = below S5, 1 = S5, …, 6 = S7, and 7 = above S7 level) as collected from the questionnaire survey

Key component	Physics	Chemistry	Biology
1. Depth of content knowledge	3.7 (1.0)	3.9 (0.9)	4.1 (1.0)
2. Breadth of content knowledge	4.2 (1.3)	4.1 (1.1)	4.3 (1.1)
3. Generic capacity	4.1 (1.2)	3.7 (1.1)	4.3 (1.1)
4. Scientific attitudes	4.0 (1.2)	3.7 (1.3)	4.3 (1.2)
5. Scientific investigation	4.3 (1.3)	4.1 (1.1)	4.5 (1.1)
6. Practical manipulative skills	4.0 (1.2)	3.8 (1.0)	4.2 (1.1)
7. Inquiry ability on STSE issues	4.1 (1.4)	4.0 (1.1)	4.3 (1.2)
8. Understanding of NOS	3.9 (1.2)	3.7 (1.0)	4.3 (1.3)
9. Problem-solving ability	4.0 (1.2)	N/A	N/A
10. Values towards living things	N/A	N/A	4.0 (1.4)

The survey of the Chemistry teachers yielded a statistically significant difference across the eight components of level required in the NSS Chemistry curriculum, with sig. = 0.004 for the F-test with $F(8,894) = 2.97$. The academic level of the new chemistry graduates was also believed to lie at around the middle point between that of current S5 and S7 graduates. However, the perceived level for some components like generic skills, scientific attitudes, and understanding of NOS (with average score of 3.7) was lower than that of subject breadth, scientific investigation, and inquiry ability on STSE issues (with an average score of 4.0 to 4.1). This result is consistent with what teachers perceived as the emphases of the curriculum. As discussed therein, the teachers perceived that NOS and scientific attitudes were less emphasized in the curriculum. Most interviewees teaching chemistry recognized the importance of conducting experiments in developing students' generic skills and scientific attitudes as commonly advocated in science education (see, e.g., Alsop, Bencze, and Pedretti, 2005; Amos and Boohan, 2002; Bennett, 2005); however, the chances of performing individual experiments would be far less than those in AL due to time and resource limitations.

With regard to the standard intended to be achieved by NSS graduates in Biology, no statistically significant difference (with sig. = 0.15 for the F-test with F(8,970) = 1.51) across the nine components appeared. However, most teachers agreed that it is closer to the standard of the HKAL (Hong Kong Advanced Level) than that of the HKCE. Students were expected to attain the highest level in their ability to undertake scientific inquiry, followed by their ability to explore STSE issues (4.53), and their breadth of knowledge (4.45). The outcome to which the lowest standard was prescribed by the respondents was the depth of knowledge acquired by students (3.97), although it was still nearer the A-Level standard than that of the HKCE. These findings were supported by the data collected from the teacher interviews. The actual standard that could be achieved by graduates of the HKDSE in Biology as perceived by the teachers seemed to be lower than the perceived intended standard. Nevertheless, for all the criteria reported previously, the perceived standard of attainment was still slightly closer to the standard of the HKAL than to that of the HKCE. Again, the highest standard to be achieved by students was ascribed to the students' ability to conduct scientific inquiry (3.93), and the lowest to the depth of knowledge (3.56).

Across the three science subjects, the average scores for almost all components (except the depth of content knowledge) in Physics generally lie between those of Chemistry and Biology. For many components (including generic capacity, scientific attitudes, practical manipulative skills, and understanding of NOS), the average scores of Chemistry teachers are found to be statistically lower than those of Biology teachers, but there is no similar finding for the Physics teachers. In comparison to the expected level achieved by their own NSS graduates in 2012, the science teachers gave the scores that those for the eight to nine components would be statistically lower than the corresponding scores for their perceived level required by the curriculum (through the t-test for every component).

4 Teaching the core and elective parts

For Physics, most interviewees agreed that the curriculum contents for the core and elective parts are quite acceptable. They expressed good confidence in teaching the core topics and the Atomic World and the Energy electives, which are very typical and have already been covered in their past undergraduate physics program. For offering various electives, many interviewees said that their schools will consider various factors or criteria, such as the availability of expensive equipment and facilities, expertise of the Physics teachers and their workload, public examination, and student interest or preference. The expertise or willingness of teachers to teach the electives will be the most important factor, whereas student feedback (from very few schools) will be used for reference only. Based on these observations, most schools will offer two electives only, with the Atomic World as one of them because it is already largely covered in the existing A-Level Physics syllabus and poses no problem about the teacher's expertise and the equipment. For the other electives, many schools favor the Energy elective based on the same aforementioned reasons; however, some Physics teachers consider the Energy elective as less challenging/interesting because they believe it overlaps with the Energy Technology and the Environment module in the Liberal Studies subject (CDC and HKEAA, 2007e). Instead of the Energy elective, some schools are considering the Astronomy and Space Science elective, because it is more interesting to both teachers and students. For the Medical Physics elective, most interviewees indicated that their schools will not offer it at all because the Physics teachers lack the subject knowledge and the schools cannot afford the expensive facilities.

For Chemistry, most interviewees agreed that the depth and breadth of the curriculum was appropriate, but they worried about the students' abilities as there was no elimination in CE level anymore. Electives would be difficult for less able students, although the core part, abstract concepts like describing and drawing three-dimensional diagrams to represent shapes of the different molecules such as CH4, NH3, H2O, BF3, PCl5, and SF6 in Microscopic World II, would be an obstacle for students. Another concern was the curriculum articulation to university, as the depth was inadequate and some concepts would not be taught in the selection electives. Controversial views on the elective emerged: Two interviewees opined that electives could be used as a way to select students in public examination, and could cater for students' learning diversity, as less able students could handle the questions of the core part in public examination. Three interviewees opined that Analytical Chemistry should be included in the core part instead of being made an elective, because it was a key element in Chemistry and many schools would choose it. Many reflected that electives could not be used to cater for individual interests and needs because they are chosen by the schools and the teachers rather than the students. Two interviewees strongly opposed electives under the consideration of the fairness in public examination, because the regulation of marks in different electives was not cleared. In addition, students already have the right to choose subjects, and there is no need to choose electives within the subject. All interviewed schools would choose Analytical Chemistry and Industrial Chemistry as electives, except one school that has not decided yet. Their rationales for choosing these two as electives were quite common, including the expertise and confidence of teachers in teaching the electives, student abilities, availability of teaching resources, and past examination papers. They would not choose Materials Chemistry due to unfamiliarity with the topic, which coincides with the questionnaire results that respondents were the least familiar with Materials Chemistry among the three electives; lack of teaching materials compared to the other two electives; large demand in memorizing factual information; difficulty in grasping the key points in public examination; and the perception that Materials Chemistry is a boring topic because it does not involve many experiments. One interviewee opined that Materials Chemistry might be chosen after accumulating examination papers from several years ago; meanwhile, another interviewee indicated that extra time would be used to teach talented students all the electives so they could have more choices in dealing with the examination. The question of the necessity of electives if almost all the schools would choose Analytical Chemistry and Industrial Chemistry was also raised.

For Biology, like other science subjects, the interviewees agreed almost unanimously that the curriculum contents of the core and elective parts are appropriate. One interviewee maintained that some A-Level topics such as the Krebs cycle may be too difficult for students and should be treated in the elective part. That said, some teachers did not believe that the electives could provide genuine choices for students, as the choice rests with the school or teachers rather than students. Some teachers hold the view that the elective part could cater for the need of average students who may be uninterested in a more in-depth study of biology, and allow the teacher to teach according to their expertise; on the other hand, others expressed their concern that students may miss some important topics. For the choices of electives, the interviewees adopted a wide range of criteria for selecting the two electives to be offered to students. These criteria included the expertise and confidence of teachers in teaching the area; interest and usefulness of the electives to students; impact and importance of the topic, its relevance to the human body (e.g., human physiology) and everyday life and conservation (e.g., applied ecology); complexity of the topic, whether the practical work involved is too abstract (e.g., biotechnology); difficulty of past examination questions with regard to that topic; availability (or unavailability) of resources; and safety in experimental work (e.g., microbiology).

5 Progression of contents

From the interview findings, most Biology teachers interviewed were concerned about whether students at Form 4 level could understand contents previously taught at the A-Level, for example, the sub-cellular structures in the topic of "The Cell." Despite this concern, most teachers would choose to complete the entire topic in one go rather than covering the basic parts of all topics first before teaching the more advanced parts as they are practicing now. The reason is that the teachers worried that if they divide the curriculum into basic and advanced parts, students will find it confusing and incoherent, hence making the contents even more difficult to understand. However, they did perceive progression as a challenge. To overcome this challenge, the teachers suggested different solutions, such as teaching simpler topics (e.g., digestion) first, followed by more complicated ones (e.g., photosynthesis and respiration); teaching more complicated concepts recurrently to consolidate students' understanding; and allowing less able students to achieve less instead of requiring all students to achieve all the learning outcomes specified in the curriculum.

For Chemistry, most interviewees responded that they would teach the core part first, followed by the elective part so that less able students could change to Combined Science if there is such a need. Some would integrate the core part and elective parts, for instance, by teaching industrial Chemistry after the rate of reaction and equilibrium, for students to have the foundation and acquire the basic knowledge and concepts required for an in-depth treatment of the prescribed industrial processes.

For the interviewees teaching Physics, their teaching sequences would vary, with many starting with mechanics and some with heat. When asked whether they will adopt a spiral learning approach in which the basic concepts will be taught in the first year and the more difficult/advanced revisited in subsequent years, most interviewees prefer to complete the whole topic within an academic year, because they believed that their students would easily forget the concepts learned in previous years. Many of them noticed that some sub-topics like momentum should better be taught before the heat topic, but the reality might forbid them to do so. The topics of Electricity and Magnetism will likely be taught in the second year when most of the core content should have been completed. The electives will be offered in the final year, and this arrangement will also allow more time for the teachers to prepare teaching materials, and for the schools to acquire the necessary facilities.

In sum, the interviewees shared the challenge in planning for progression of the topics to be taught in their respective subjects. Most interviewees tended to adopt a more pragmatic approach by teaching the topics one by one, which means that both the basic and advanced concepts within a topic will be dealt with at the same time instead of organizing the concepts in the form of a spiral curriculum in which the same topic will be revisited at different times of the course. Nevertheless, some interviewees opined that this option might not be the ideal way of teaching and learning certain topics where there is a large cognitive gap between the basic and advanced concepts.

6 Progression from the junior to senior secondary level

There appeared to be a strong tendency among the interviewees to prepare students to learn NSS Biology by helping them build a solid foundation at junior levels. Some teachers had put more emphasis on scientific investigations in Forms 1 to 3, and let the students progressively practice the skills of inquiry (e.g., writing reports, conducting fair tests, and formulating hypotheses). Other teachers had incorporated the three separate science disciplines into Form 3 science classes to familiarize students with basic biological concepts such as cells and enzymes. Some teachers maintained that in light of time constraints at the senior secondary level, the development of scientific investigative skills should start progressively at lower forms on the understanding that if students have built a good foundation in their junior secondary years, learning will be more effective as they progress to senior forms. The following extract from an interviewee illustrates this kind of thought:

> *"I think it is important for schools to plan for progression with respect to the teaching of scientific inquiry so as to pitch the inquiry activities for junior and senior forms at appropriate levels of difficulty. Students could begin*

> *with handling variables in experiments, and then slowly progress to discussion, analysis, and drawing conclusions, like what sixth formers are doing now."*

These views of the Biology teachers were largely shared by their Chemistry counterparts who generally acknowledged that building a solid foundation at junior levels is helpful for students to learn NSS Chemistry. Some teachers would engage students in practicing the skills of inquiry through different inquiry projects, such as measuring the calcium contents in trotters, or sugar contents in coke, and studying the effect of acid rain on plants. Many replied that some topics from the Form 4 Chemistry curriculum such as planet Earth and microscopic world could be taught in Form 3.

Most interviewees teaching Physics did not consider the junior secondary science could greatly help in preparing for the new senior Physics curriculum; nevertheless, their schools have implemented separate science curricula (instead of an integrated science curriculum) at the S3 level. The importance of the S3 Physics curriculum was to let students experience the Physics subject so that they could make a proper choice at the senior secondary level. Most interviewees expected that fewer students than previously will select the Physics subject because it is more difficult compared to other science subjects. Additionally, the number of elective subjects (either two or three) for students to choose from at the NSS level is limited.

7 Dealing with mixed ability

To overcome problems created by mixed ability teaching, teachers of all the three science subjects suggested similar strategies. From the questionnaire survey (Table 5), the three most commonly suggested strategies for handling mixed ability are the same across all subjects. They are, in descending order of preference: organizing tutorial classes for less able students (73 to 80%), conducting supplementary classes for all students after school (66 to 72%), and tailoring the curriculum content to the ability of students (50 to 55%). In dealing with mixed ability, the teachers emphasized the lower end of the ability spectrum rather than the upper end as indicated by a much lower proportion of teachers suggesting activities for the more able students (28 to 38%). Other strategies that are fairly popular among the teachers are designing and selecting suitable teaching materials for students of different abilities (42 to 52%), and allowing students to drop the subject that is too difficult for them, or switch to another subject (44 to 49%). The least popular methods suggested by the teachers of all the three subjects were allowing students of different abilities to use different textbooks (12 to 22%), allowing students to choose either English or Chinese as the medium of instruction (19 to 22%), and using homogenous grouping (16 to 21%). Teachers of all the three science subjects seemed to prefer heterogeneous grouping (23 to 34%) to homogeneous grouping in catering for mixed ability, although they did not regard grouping as a high priority among other strategies. From an exploratory factor analysis, it is found that the first 13 items (as commonly included in the questionnaire instrument for the 3 types of science teachers) are sorted into 4 factors (each with an eigenvalue greater than one). The factor 1 involves items #5-6 and #8-10 and they characterized by their reference to the student abilities. Factor 2 contains items #1, #2 and #3, referring to the arrangement of special classes or tasks for more able or less able students. Factor 3 is positively correlated with items #3 and #8 but negatively correlated with item #7, indicating the choice of medium of instruction is incompatible with homogeneous grouping and tailoring of teaching materials. For the last factor which is simply a drop-out approach, it involves items #11 and #12.

From the findings of the interviews with teachers, the challenge to manage students of mixed abilities seemed to be a prime concern of most interviewees, regardless of the subject they teach. The interviewees, especially those teaching Biology and Chemistry, agreed almost unanimously that catering for the needs of students with mixed abilities given the large class size is difficult. Most agreed to pitch their day-to-day teaching at the level of the average students, while providing extension tasks for the more able, and after-school tutorials or remedial classes for the less able. Other strategies to cater for mixed abilities include differentiating class work and homework into core and extension parts; differentiating the learning outcomes into progressive levels of attainment; providing more guidance for less able students in the form of questioning; challenging the more able ones with further readings and past papers of overseas examination; and grouping students in a heterogeneous manner so that the more able students could help their less able counterparts. Another major concern about mixed ability teaching is the need to adapt the medium of instruction to the needs of students. Thus, it is likely that the medium of instruction will be an important variable influencing the implementation of the NSS curriculum. These strategies largely concurred with those obtained from the questionnaire survey. Teachers would also consider letting less able students change to Combined Science (CDC and HKEAA, 2007f), which is extracted from the core components of two of the three traditional science subjects, or dropping the subject that they feel incapable of studying. Two interviewees who teach Chemistry opined that differentiating the curriculum contents into core and electives could be considered as a means to cater for students' learning diversity as less able students could handle the core part in the public examination, whereas the more able students are capable of attempting the questions on the elective parts.

Table 5. Strategies for dealing with learning diversity in teaching science subjects

Strategy	Physics	Chemistry	Biology
1. Supplementary classes after school	69%	72%	66%
2. Remedial class for the less able	80%	79%	73%
3. Homogeneous grouping	16%	16%	21%
4. Heterogeneous grouping	23%	21%	34%
5. Tailoring assessment modes and standards to student ability	35%	35%	32%
6. Using different textbooks for students of different abilities	18%	12%	22%
7. Allowing a choice of English or Chinese medium of instruction	19%	27%	22%
8. Tailoring teaching materials to student ability	52%	42%	47%
9. Adapting curriculum contents to cater for mixed abilities	55%	50%	54%
10. Streaming according to student ability	13%	20%	14%
11. Allowing students to drop subjects if proven too difficult for them	44%	49%	46%
12. Allowing students to change pure science subjects to Combined Science	18%	34%	29%
13. Extension tasks for the more able students	28%	35%	38%
14. Extended curriculum for the more able students	30%		

For Physics particularly, most of the interviewees worried about the widening of student ability in future Physics classes. The reason is that the current Cert-Level examination serves to screen the less able students, and those students who choose the A-Level Physics subject are really interested in Physics. Many hold the view that Combined Science provides a feasible alternative for less able students to fall back on if they have to drop Physics. Moreover, students will not have their time wasted as the core topics taught in the S4 Physics are just the same as those covered by Combined Science. This idea concurs with the questionnaire survey in which 44% of respondents will allow students to drop the subject or transfer to other subjects. Moreover, many interviewees reflected that their schools adopted a strategy of providing a more challenging curriculum to the able students, and extra tuition to the less able ones. This finding is again consistent with those of the questionnaire survey in which the latter is the most favorable strategy adopted by 80% of the respondent schools.

These findings show that the respondents of all the three science subjects were greatly concerned with the increased diversity of students taking NSS science subjects in terms of academic ability. The lower end of the ability spectrum was apparently a greater cause for concern than the upper end. A variety of strategies were suggested by the respondents to alleviate the problem. Many teachers seemed to be prepared for switching students to Combined Science, or even allowing them to withdraw from their subject entirely. From the findings, the issue of mixed ability teaching has implications not only for the curriculum and teaching methods, but also for timetabling, the medium of instruction, students' choice of elective subjects, and their study path in the last three years of secondary schooling.

8 Pedagogy

Table 6 (under a four-point Likert scale with 1= will not use and 4 = will always use) reveals the pedagogy that science teachers would use in NSS. An exploratory factor analysis has been done on the first ten items which are commonly used in the questionnaire instrument for the 3 groups of science teachers. There exists only one factor (with an eigenvalue greater than 1) which is positively correlated with items #4 and #8 but negatively correlated with item #1, implying that the adoption of those new student-centred teaching strategies like problem-based learning and concept map construction are somewhere incompatible with the traditional teacher-centred strategy of exposition which is the most popular one. As there is no other factor formed for the remaining items, there seems to be no significant correlation between the use of the those teaching strategies.

For interviewees teaching Biology, content knowledge would still be the emphasis, and they commended the repertoire of pedagogical approaches suggested in the curriculum guide. However, the availability of time was expected to be a major factor to determine whether these approaches could be utilized or not, although most interviewees agreed to practice these approaches where circumstances permit. Therefore, with the support of quantitative data, exposition (3.6) would remain the most popular approach used in teaching NSS Biology, followed by inquiry and experimental activities, information search, construction of concept maps, problem-based learning, interactive learning using information technology (IT), and learning through reading. The least popular approach is the historical approach (2.20). Rather surprisingly, life-wide learning and project learning (both 2.50) did not seem to be highly regarded among Biology teachers despite the wide publicity they received in recent years.

For Physics, the questionnaire survey revealed the existence of a statistically significant difference (with $F(10, 1042) = 24.01$ or sig. = 0.000) in the likelihood of adopting various teaching methods. The most favorable ones are the traditional narrative approach and the experiment and scientific investigation activities. The least favorable two are life-wide (or field-based) learning and the construction of concept maps. Most interviewees said that they would not make any significant changes in their teaching approaches even though they may add a few issues and daily application examples in their teaching materials.

Just like Physics, experiment, scientific inquiry activities and traditional narrative approach are also the two most highly adopted pedagogies of Chemistry, which scored an average of 3.7 and 3.6, respectively, in the questionnaire survey. Moreover, many interviewees would not or seldom use life-wide learning, and some even did not recognize life-wide learning. One interviewee mentioned that the definition and the position of life-wide learning were unclear. The findings coincide with the questionnaire that life-wide learning scored an average of 2.1 would be the least used pedagogy in teaching NSS Chemistry.

Table 6. Average scores (with standard deviations given in parentheses) for pedagogy that science teachers would use in NSS (in a four-point Likert scale) as collected from the questionnaire survey

Pedagogy	Physics	Chemistry	Biology
1. Exposition	**3.4(0.59)**	**3.6(0.56)**	**3.6(0.6)**
2. Concept map construction	**2.5(0.77)**	**2.7(0.64)**	**2.8(0.61)**
3. Searching for and presenting information	**2.8(0.69)**	**2.7(0.58)**	**2.9(0.57)**
4. Reading to learn	**2.6(0.62)**	**2.5(0.67)**	**2.8(0.59)**
5. Group discussion/role play/debate	**2.7(0.67)**	**2.2(0.67)**	**2.5(0.63)**
6. Experiments and scientific inquiry activities	**3.4(0.60)**	**3.7(0.48)**	**3.3(0.62)**
7. Project	**2.7(0.64)**	**2.6(0.67)**	**2.5(0.60)**

8. Problem-based learning	**3.0(0.80)**	**2.9(0.81)**	**2.8(0.80)**
9. IT for interactive learning	**2.9(0.64)**	**2.8(0.78)**	**2.8(0.80)**
10. Life-wide learning (including field trip)	**2.3(0.62)**	**2.1(0.70)**	**2.5(0.56)**
11. Context-based learning	**2.6(0.72)**	**--**	**2.4(0.65)**
12. Historical approach		**--**	**2.2(0.56)**
13. Issue-based learning	**--**	**2.1(0.66)**	**2.5(0.62)**

9 School-based assessment

All science subjects will have school-based assessment (HKEAA, 2009), which comprises both practical components including "Investigative Study," and non-practical components such as critical reading, analysis and reporting, designing a poster or pamphlet, writing a report, and developing a multimedia artifact. The marks of both components will contribute to 20% of the final subject marks in the NSS public examination. The introduction of SBA replaces the former Teacher Assessment scheme (TAS), which mainly assessed students' practical skills is in the hope of developing students' generic skills. However, given the number of difficulties faced by the schools in the SBA implementation and the awareness of Physics teachers that written papers in the public examination are in fact much more important in determining the final scores of SBA and the overall subject grade, the SBA could merely serve as an instrument for putting relative positions or ranks among students in their schools. However, the range of scores is so small that it has a negligible effect on the students' final grades. Thus, the teachers would rather spend more time and efforts in training their students in mastering the techniques or tricks of tackling public exam questions. Physics teachers also raised a common concern about the lack of sufficient equipment for holding the SBA in a class of about 40 students compared to only 30 in the existing A-Level TAS. The reason is that Physics experiments often require different dedicated apparatus or equipment that is fairly expensive that each school can normally afford to purchase two sets for all students to conduct the experiments on a rotation basis. This may become an unfair practice in the SBA implementation as some students may have done the experiments (or used the equipment or apparatus) before, whereas others may not have a chance to do so.

Most interviewees teaching Biology supported SBA in principle, but envisaged difficulties when it is put into practice (e.g., large class size and time and manpower constraints, hence putting a lot of pressure on teachers. The advantage of SBA perceived by the teachers is that students would be better motivated in doing practical work and acquire a wider range of skills. One teacher mentioned that the accountability of teachers will also be enhanced. However, on the negative side, the interviewees were concerned about the issues of fairness, validity, and reliability, and the pressure created by SBA on students. One argued that the use of examination scores to moderate student performance in SBA is unfair. Exacerbating these problems is the technical difficulty in assessing a large class of students. Furthermore, students will experience great pressure as they will be assessed in different subjects.

For Chemistry teachers, most of them agreed with SBA in principle, but would encounter similar implementation difficulties faced by Biology and Physics teachers (e.g., large class size; limited time; too many SBAs; manpower constraints, especially those pertaining to laboratory technicians; limited resources in carrying out an investigative study; and experiments about titration). In addition, interviewees expressed certain concerns such as laboratory safety because students lack basic laboratory techniques; fairness of SBA; plagiarism in investigative study and reports; and the possibility of students giving up the marks in investigative study because it only carries 20% of SBA. Moreover, although inquiry experiment is part of the SBA, its mode of execution is different from that of the TAS. Teachers conveyed difficulty in designing appropriate inquiry activities for students. Aside from the practicability concerns of the experimental part, two extreme views toward the addition of the non-practical part among Chemistry teachers were put forward. Some reflected that such an addition could cater for different students' abilities as the variety of assessment modes increases, broaden students' learning aspects, and enhance their communication skills. On the other hand, other Chemistry teachers pointed out that the manpower cost would be very high when the assessment is too diversified; fairness in the non-practical part would become an issue as different schools would have different assignments; and the marking is subjective with different relative levels in Chemistry.

Most of the science teachers in this study are highly concerned about SBA implementation. Although most of them agree with its implementation rationale, they are unsure about its fairness, authenticity, and accountability. Moreover, difficulties like large class size and insufficient equipment are also hindering schools from implementing SBA.

Conclusion and implications

In sum, we interviewed a total of 11 curriculum planners and 45 school teachers, and collected questionnaire survey data from over 400 school science teachers before the implementation of the NSS science curricula in Hong Kong. Science teachers' understanding of the teaching methods, SBA, and public examination in their respective subjects were generally satisfactory. However, teachers showed a significantly lower level of content knowledge understanding toward certain electives. Furthermore, schools or teachers would choose the electives for the science subjects, and the choices are mostly constrained by the expertise of teachers, their tendency to adhere to past practices, and the limitation of resources instead of student interest. Under the pressure from a single public examination, tackling public examination would be the most significant consideration in choosing electives. Therefore, the government's rationale for broadening students' learning experiences and catering for individual differences by offering electives within science subjects is apparently difficult to achieve unless additional resources are allocated to schools to purchase expensive equipment, and more in-service professional development courses are offered to enrich the subject knowledge of science teachers in those electives.

Traditional exposition and experiments/scientific inquiries activities would remain the two most highly adopted pedagogies among science teachers in NSS. However, the deductive approach to verifying theories instead of the inductive approach would be used because most of the science teachers rely on cookbook-style experimental workbooks developed by publishers. Given the limited time and resources, teachers would focus on drilling examination techniques rather than developing inquiry teaching materials. As a result, there would be no significant changes in pedagogy. Therefore, various innovative teaching methods (e.g., Frost, 2010; Ross, Lakin, and McKechine, 2010; Yeung, 2002) and technology-enhanced learning or computer-mediated experiments should be more widely incorporated into the teaching and learning of various science subjects.

As to the progression of the curriculum, teachers were aware of the extra cognitive demand placed on students to learn a topic at one time instead of following a spiral curriculum as in the old 2 + 2 (i.e., S4-5 Cert Level + S6-7 A-Level) curriculum. Being consistent with the current view on scientific literacy (AAAS, 1990; Millar, 2006), the respondents contemplated the building of a solid foundation in junior students to facilitate their transition from junior to senior science in different ways, including teaching separate science subjects in Secondary Three, and incorporating inquiry-based learning in junior forms. For the past few years, the EDB has funded some local tertiary teacher education institutions to provide this type of on-site school-based support to the junior and senior secondary forms in a number of secondary schools for the preparation of the NSS Liberal Studies subject. A similar kind of support should be extended to the science KLA, particularly for the NSS Integrated Science subject (CDC and HKEAA, 2007d), for which no textbook was released by any commercial publisher.

Nearly all respondents were greatly concerned about the increased diversity of students in terms of their ability and interest in learning science at senior levels. This problem could be tackled through a variety of means, with the most popular ones being conducting after-school supplementary classes and remedial classes for the less able students. As a final resort, teachers seemed to be ready to allow students to switch to the Combined Science subject, or even drop the subject if they experience too great a difficulty in mastering the subject concerned.

To tackle the manpower problem in implementing SBA, technicians will play an important role in deploying an investigative study of SBA across three science subjects. Some schools might invite technicians to guide or supervise an investigative study, and this might lead to other issues such as whether technicians have received sufficient training in supervising scientific projects, share the same rationale for developing students' generic skills, and possess appropriate attitudes toward science and accountability. Some science teachers might also face the problem of assessing non-practical elements in SBA because this is different from traditional paper-and-pen assessment and they have not had any similar experience before.

Finally, the findings from this study could be taken as a useful reference for comparison with future review or evaluation of the NSS science curricula after their initial implementation. As Hong Kong students have been ranked atop several famous international comparative studies in science and mathematics like TIMSS (IEA, 2011) and PISA (OECD PISA, 2011), further investigation of the impact of the NSS on students' academic performance in science subjects will be an interesting topic of research in the science education field.

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Appendix

Appendix I. Interview Instrument

Interview Questions (for Phy/Chem/Bio Teachers)

I. **Background information**
   1. Teaching experience
   2. Years of service in the present school
   3. Teacher training

II. **Preparation by the school for teaching NSSC**
   1. Which science subjects will your school going to offer? How does your school decide the science subjects to be offered (e.g. Integrated Science, Combined Science?)
   2. Are there any changes in the F1-3 science curriculum of your school in order to prepare students for the NSS?

III. **Preparation by teachers for teaching their specific NSS subject**
   1. How familiar are you with the NSS subject curriculum? Which parts are you less familiar with?
   2. What training courses have you attended? How useful were they?
   3. What areas/aspects of training do you think are still needed?

IV. **Content and organization of the New NSSC (Phy/Chem/Bio)**
   1. What are the major differences between the existing (CE/AL) and the NSSC?
   2. What do you think about the foci of the new curriculum (with respect to aims, contents, teaching approach, assessment, etc.)?
   3. The NSSC emphasizes "scientific inquiry", "STSE connections" and "Nature of science"? Do you agree with these emphases? Are they feasible in your context?
   4. How do you think about the introduction of elective parts in the subject?
   5. Do you think the contents of the core and elective parts are appropriately chosen and articulated?
   6. Are the elective parts suitable for your students and meet their interest and learning needs?
   7. How would your school make the choice of elective modules?

V. **Teaching**

1. What would be your own emphases in planning and teaching the new subject?
2. What teaching strategies would you emphasize in teaching NSSC?
3. How are you going to structure and organize the curriculum contents, particularly the more advanced contents and topics (e.g. formerly AL topics)?
4. How would you cater for students of mixed abilities in your subject?

VI. **Assessment**

1. What do you think about SBA? Is it achievable? How far would you support it (the experimental and non-experimental parts)? How would you prepare students for both SBA and the public written exam?

VII. **Resource implications**

1. What resource implications would the school have in NSS?
2. What roles do you think the laboratory technician(s) shall play in the NSS?
3. What other difficulties would you foresee in teaching NSS? How would you overcome them?

VIII. **Coordination with other NSS subjects**

- Would there be any coordination in your school in the teaching of NSS subjects that are inter-related? (E.g. Physics/Math, Sciences/LS, etc)

IX. **Outcomes of Learning**

1. What are the perceived levels of attainment of NSS graduates when compared to those of CE or AL graduates in terms of
   - scientific knowledge and inquiry skills;
   - generic skills (e.g. critical thinking, collaboration, learning ability, IT, problems solving, mathematical ability etc.);
   - scientific attitudes, learning attitudes and
   - language/communication competency.
2. Compared with other NSS subjects (science or non-science), how do you rate this subject in terms of
   - opportunities for further studies;
   - career prospect and
   - interest in taking this subject.

Appendix II. Parts of the Questionnaire Instrument for Physics Teachers

Questionnaire Survey of New Senior Secondary Curriculum - Physics

6. What is your level of understanding of the physics curriculum?	Very low level of understanding					Very high level of understanding
	1	2	3	4	5	6
A. Elective content knowledge	☐	☐	☐	☐	☐	☐
a. Astronomy and space science	☐	☐	☐	☐	☐	☐
b. Atomic world	☐	☐	☐	☐	☐	☐
c. Energy and use of energy	☐	☐	☐	☐	☐	☐
d. Medical physics	☐	☐	☐	☐	☐	☐
B. Teaching methods	☐	☐	☐	☐	☐	☐
C. School-based assessment	☐	☐	☐	☐	☐	☐
D. Public examination	☐	☐	☐	☐	☐	☐

7. How would you deal with learning diversity in teaching physics? (You may choose more than one option)

a.	Supplementary classes after school	☐
b.	Remedial class for the less able	☐
c.	Homogeneous grouping	☐
d.	Heterogeneous grouping	☐
e.	Tailoring assessment modes and standards to student ability	☐
f.	Using different textbooks for students of different abilities	☐
g.	Allowing a choice of English or Chinese medium of instruction	☐
h.	Tailoring teaching materials to student ability	☐
i.	Adapting curriculum contents to cater for mixed abilities	☐
j.	Streaming according to student ability	☐
k.	Allowing students to drop subjects if proven too difficult for them	☐
l.	Allowing students to change pure science subjects to Combined Science	☐
m.	Extension tasks for the more able students	☐
n.	Extended curriculum for the more able students	☐
o.	Others (Please specify:________________________________)	☐

8. What is your level of emphasis for the following aspects of the NSS physics curriculum?	Very unimportant	Very important

	1	2	3	4	5	6
a. Disciplinary content knowledge	☐	☐	☐	☐	☐	☐
b. Disciplinary practical and investigation skills	☐	☐	☐	☐	☐	☐
c. NOS	☐	☐	☐	☐	☐	☐
d. Inquiry of STSE issues	☐	☐	☐	☐	☐	☐
e. Scientific attitudes	☐	☐	☐	☐	☐	☐
f. Problem-solving ability	☐	☐	☐	☐	☐	☐

10. How often will you adopt the following teaching methods?	Never	Occasionally	Sometimes	Regularly
a. Exposition	☐	☐	☐	☐
b. Concept map construction	☐	☐	☐	☐
c. Searching for and presenting information	☐	☐	☐	☐
d. Reading to learn	☐	☐	☐	☐
e. Group discussion/role play/debate	☐	☐	☐	☐
f. Experiments and scientific inquiry activities	☐	☐	☐	☐
g. Project	☐	☐	☐	☐
h. Problem-based learning	☐	☐	☐	☐
i. IT for interactive learning	☐	☐	☐	☐
j. Life-wide learning (including field trip)	☐	☐	☐	☐
k. Context-based learning	☐	☐	☐	☐

11. How do you perceive the level of the NSS physics curriculum?	< F.5	F.5 1	2	3	4	5	F.7 6	> F.7
a. Depth of content knowledge	☐	☐	☐	☐	☐	☐	☐	☐
b. Breadth of content knowledge	☐	☐	☐	☐	☐	☐	☐	☐
c. Generic capacity	☐	☐	☐	☐	☐	☐	☐	☐
d. Scientific attitudes	☐	☐	☐	☐	☐	☐	☐	☐
e. Scientific investigation	☐	☐	☐	☐	☐	☐	☐	☐
f. Practical manipulative skills	☐	☐	☐	☐	☐	☐	☐	☐
g. Inquiry ability on STSE issues	☐	☐	☐	☐	☐	☐	☐	☐
h. Understanding of NOS	☐	☐	☐	☐	☐	☐	☐	☐
i. Problem-solving ability	☐	☐	☐	☐	☐	☐	☐	☐